existence of status lymphaticus in these cases, we can suggestively recall the fact, repeatedly emphasized by those who have occupied themselves with that peculiar morbid condition, viz., that a tendency to sudden and usually fatal œdema—as of the larynx, lungs or brain—is one of the outstanding peculiarities of the victims of the lymphatic constitution. Accordingly, the observations here recorded should tend in two directions—to emphasize the importance of acute œdema of the lungs as a concurrence in epilepsy, and further to illustrate the kinship between certain types of epilepsy and status lymphaticus.

THE PHYSIOLOGICAL UTILIZATION OF SOME COMPLEX CARBOHYDRATES.

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It is still a current practice, especially among medical men, to look upon the proximate analysis of a food material as an adequate index of its nutritive value. In certain cases the data thus gained may be depended upon to give reliable information regarding food values; in others, however, the chemical statistics derived from the more familiar analytical procedures can become quite misleading. The explanation of this lies in the fact that much of the information furnished by the analyst is indirect in character. Protein is estimated on the basis of nitrogen content. This method may lead to erroneous conclusions in the case of plant products in particular, in which a diversity of nitrogenous constituents other than proteins are frequently present. The ether extract is designated as fats, although it is known frequently to contain lipoids, notably phosphatides, the real nutritive value of which is uncertain. The carbohydrates are not infrequently estimated by difference—a method which not only is subject to inherent error, but also fails to give any indication of the specific character of the substances represented.

An illustration of the illusory character of such analyses is afforded by the investigations of one of us upon mushrooms. These are highly prized in certain quarters because of a supposed richness in protein which is attested by a considerable content of nitrogen. Experimental studies have shown, however, that the latter is present in indigestible form, in part as nitrogenous celluloses; any representations of composition made on the basis of such analytical determinations as have just been reviewed are obviously misleading.

Turning to the most abundant nutrient group in the dietary, there are additional reasons why even an accurate identification of the carbohydrate nature of a food component is no guarantee of its nutritive value. Aside from the fact that ofttimes the individual nutrients are presented in the naturally occurring foods in a form which renders their alimentary utilization difficult on mechanical or physical grounds, numerous carbohydrates are *per se* indigestible. In the case of cellulose this has been distinctly appreciated. It has been one of the contributions of the more recent physiological investigations to emphasize, (1) the need of digestion of foodstuffs prior to their utilization, and (2) the *specific* action of enzymes in virtue of which they are selective, as it were, toward certain substrates. An illustration of these facts may be taken from the behavior of the different sugars. Cane sugar, for example, is not utilized by the organism unless it is inverted to the six-carbon sugars, dextrose and levulose. Since the alimentary tract is the only part of the body equipped to carry out this reaction, cane sugar is not readily utilized unless it is introduced enterally in the body. The specificity of the inverting enzymes is exemplified in the observations that not all disaccharide sugars are inverted, that is, digested, with equal ease by the digestive secretions; and in certain species of animals, or at definite stages of development, one or the other of the characteristic inverting enzymes may be wanting. One of us has shown this to be the case in the equipment of alimentary enzymes in the embryo as contrasted with later stages of growth. The fact that the saliva of certain animals, the dog and cat for example, is devoid of amylolytic power is likewise suggestive in this connection.

At various times attention has been directed to the introduction into wider use of a great variety of food products rich in carbohydrates, which differ especially from the more familiar types in containing in place of starches and sugars a diversity of less common carbohydrates, such as polysaccharides of galactose, mannose, pentose, methyl pentose, dextrose, etc. These are widely distributed in plants and have been heralded as suitable food preparations under varied circumstances of choice or necessity. Remembering that when a foreign carbohydrate succeeds in entering the organism proper there is no guarantee of its being retained for nutritive functions unless it has been digested and is presented in the form of a six-carbon sugar, it becomes necessary to apply the direct test of availability in the organism itself. Despite their absorption, glycogen, dextrin, starch, cane sugar, lactose, inulin, may all escape unchanged from the body unless they undergo preliminary digestion. When the actual utilization of such carbohydrates is determined by feeding trials, all the possible digestive agencies—enzymes and alimentary microörganisms—are given an opportunity to contribute toward the appropriate preparation of the food for assimilation.

The fate of a number of the carbohydrates and products containing them is already known. The starches and common sugars disappear almost completely from the alimentary tract in man, so that their "coefficient of availability" is very high. It has been shown that inulin, on the contrary, is not converted into sugar by saliva, pancreatic or intestinal extracts, although specific inulases are found in vegetable forms. Inulin can be converted into levulose by the free mineral acid of the gastric juice; and herein seems to lie its most effective opportunity for conversion to sugar in the alimentary tract. Obviously the recommendations for the dietetic use of Jerusalem artichokes or topinambur, rich in inulin, need to be subjected to experimental test. Such investigations as have been made speak against the value of these foods, despite the readiness with which they yield levulose in the laboratory. The favorable reports have emanated from observations on diabetic patients in whom ingestion of inulin has not induced any corresponding output of sugar. The error of interpretation, when the loss of the ingested carbohydrate among the undigested food residues in the feces is not taken into account, is obvious.

In another place one of us[1] has considered in greater detail some of the suggestions which have been made from time to time, and some of the current practices in regard to a diversity of unexamined carbohydrate-yielding foods. The algæ, fungi, lichens, and tree barks, as well as certain roots and tubers, are included among these. The United States Bureau of Fisheries has publicly urged that the large number of algæ "susceptible of being prepared as palatable and wholesome foods" should be given a thorough trial. Many of the genera of "sea weeds" widely used for food purposes in Japan and Hawaii are abundant on our coasts. We need only mention more familiar names, such as Iceland moss, Irish moss, dulse, laver, murlins, vegetable gelatin (agar-agar), salep, Hawaiian "limu," and Japanese "nori," to indicate the character of the materials referred to. For several years they have formed the subject of nutrition investigations in this laboratory. In the present communication the results of studies by Dr. Swartz on a series of typical products actually used in certain quarters will be reported briefly. A more detailed account with the protocols will be published elsewhere.

In one group of experiments the various products have been added to the diet of man and animals (dogs) and the utilization determined by a chemical examination of the feces. In every case, the behavior of the various carbohydrates toward enzymes (human saliva, malt and "taka" diastases, dog's pancreatic juice or pig's pancreatic extract, extracts of dog's intestines and pig's stomach), and typical bacteria (mixtures of soil and fecal bacteria, pure cultures of Bacillus coli, and other aërobes commonly occurring in the alimentary tract, and of putrefactive anaërobes) has been investigated. The fate of the constituent carbohydrates when they are introduced into dogs parenterally—with avoidance of the alimentary tract—has also been considered.

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[1] Mendel, Zentralblatt f. Stoffwechsel, 1908, No. 17; Trans. Amer. Gastro-enterological Society, 1908.

The food materials were derived largely from marine algæ, and included, besides the familiar dulse and Irish moss of our own markets, a number of species popular in the Hawaiian Islands. These were obtained through the kindness of Miss Minnie Reed, science teacher in the Kamehameha Manual Training School, Honolulu. For experimental purposes, water extracts were made whenever possible, and seaweeds which yielded no soluble carbohydrates in this way were ground in toto, and cooked before feeding. For convenience, these preparations may be grouped, according to their chief carbohydrate constituents, as follows:

Pentosans: Dulse (*Rhodymenia palmata*), and the Hawaiian algæ, limu lipoa (*Haliseris pardalis*), limu eleele (*Enteromorpha intestinalis*), limu pahapaha (*Ulva lactuca*).

Galactans: Irish moss (*Chondrus crispus*) and the Hawaiian algæ, limu manauea (*Gracilaria coronopifolia*), limu huna (*Hypnœa nidifica*), limu akiaki (*Ahnfeldtia concinna*), limu naualoli (*Gymnogongrus*), and limu kohu (*Asparagopsis sanfordiana*).

Mannan: Salep.

Levulan: Sinistrin, from the bulbs of *Scilla maritima,* known as squills.

The marine algæ named above consist chiefly of pentosans and galactans, the former being largely insoluble in water; the latter, soluble, and gelatinous in character like agar-agar.

The resistance to digestive enzymes in experiments *in vitro,* was very marked; ordinary diastatic enzymes were uniformly ineffective. With artificial gastric juice and "taka" diastase, twenty-four hours' digestion resulted in slight hydrolysis in a few instances, but control experiments with 0.2 per cent. hydrochloric acid indicated that digestion with gastric juice was due to the acid present rather than the action of any enzymes.

Bacteriological investigations showed that the carbohydrates under consideration are not readily attacked by microörganisms, but differ greatly in their ultimate powers of resistance. The galactan-containing Irish moss remained unaltered, even after a month's subjection to various species of bacteria; on the other hand, the levulan, sinistrin, and the mannan of salep were in part converted to reducing sugar by similar treatment. In the case of the soluble pentosan of dulse, no hydrolysis was observed, but decomposition gradually took place. In order of diminishing resistance to bacteria, therefore, these hemicelluloses may be said to stand thus: galactans, pentosans, levulans, mannans.

These same typical carbohydrates, introduced parenterally (subcutaneously or intraperitoneally) into dogs, were promptly excreted through the kidneys and recovered in the urine apparently unaltered, precisely as previous experience with undigested carbohydrates would lead us to expect. In our feeding experiments the percentage of carbohydrate recovered in the feces bears a striking relation to the degree of resistance exhibited toward bacterial action, expecially in the trials with human subjects. This is hardly surprising, in view of the demonstrated inability of the digestive enzymes to hydrolyze these preparations *in vitro*, and of the animal organism to utilize them without intervention of the alimentary tract. The galactans, although administered in the form of attractive and palatable blanc mange or jellies, in moderate quantities, showed an average elimination in the feces of about 75 per cent., Irish moss proving the most completely indigestible of all preparations of this group. On the other hand, the mannan from salep and the pentosan from dulse disappeared almost completely from the human alimentary tract. Preparations in which the pentosans were of the type insoluble in water, namely, those of the three Hawaiian limu—lipoa, eleele, and pahapaha—were excreted to about 50 per cent. unchanged. The utilization was, therefore, greater than has been obtained in similar experiments in this laboratory with a substance of the dextran group, *Cetraria islandica*, of which over 75 per cent. was excreted. These results warn us against drawing sweeping conclusions as to the digestibility of hemicelluloses as a class; each type must receive special consideration. At the same time, it remains to be shown, by means of respiration experiments, to what extent those hemicelluloses which do disappear from the alimentary tract in large measure (as the mannan of salep) are a true source of energy for the organism, and to what extent they are simply decomposed by bacteria into products which play at most an insignificant part in metabolism.

It is impossible to attribute much nutritive value to the galactan extracts so highly valued as demulcents and substitutes for animal gelatin, when 75 per cent. may be promptly excreted; but they may have a useful function in the dietary of persons with a tendency to constipation, by their presence, and their power of retaining moisture, giving desirable bulk and texture to the feces. This effect has been noticeable in several experiments.

There is a further possibility that those carbohydrates which do disappear in large measure from the alimentary tract may serve as stimulants to intestinal secretory activity, and so play an important rôle. An increase in the bulk of the feces was noticeable in certain experiments in which the carbohydrate had almost entirely disappeared during its stay in the alimentary tract. Many of these modern products may deserve a place in the dietary in health or disease as food accessories. It is from this point of view, rather than because of their reputed nutrient value, that they should receive notice from the student of dietetics.